# IMPROVING PRODUCTION WORKFLOW PROCESSES IN PRINTING INDUSTRY USING SIMULATION

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## ABSTRACT

In this study, it discusses about improving production workflow process in printing industry using simulation. The scope of this study is focusing on the production workflow of printing soft cover books. The time frame covered is one year it is in the year of 2013. This study is conducted by using the ARENA simulation software to simulate the modeled process in the simulation software. It is a quantitative study in which the performance is measured by the cycle time for the whole system of book printing.

*Keywords*: Cycle Time, Productivity, Utilization, ARENA Software, Simulation, Production Line, Book Printing

## ABSTRAK

Kajian ini membincangkan tentang peningkatan proses pembuatan di kilang percetakan buku dengan mengunakan kaedah simulasi. Skop kajian ini memberi tumpuan pada proses percetakan dan pengeluaran buku. Tempoh masa yang diliputi adalah satu tahun pada tahun 2013. Kajian ini menggunakan perisian simulasi ARENA untuk menjalankan proses simulasi pada model yang telah dibina dalam perisian simulasi. Kajian ini adalah kajian kuantitatif di mana prestasi diukur dengan masa kitaran dalam sistem keseluruhan percetakan buku.

*Kata kunci*: Masa Kitaran, Productiviti, Utilisi, ARENA Perisian, Simulasi, Percetakan buku

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# CHAPTER 1

# INTRODUCTION

## 1.1 INTRODUCTION

According to Dun and Bradstreet Software Services (1993), the production or manufacturing workflow consists of highly sophisticated structured processing activities, such as development of products, application for loans, engineering change orders, and insurance claims. As production workflow is task-driven, the similar activities are carried out frequently by the same workers to send the tasks to the next worker in the flow waiting for processing or approval. Production workflow is also enterprise-wide because it is driven by repeated interaction with customers and improves continuously to keep the industry updated as new needs arise.

However, with the increase of market competition, most of the industries have implicated that it is essential to increase the organization's core competency level and capability. In order to maintain competitive capability; companies have to first improve the production performance. After many years of researching, the academic researchers and industrial organizations have carried out the business process reengineering (BRP) to increase companies' operation and production. The BRP includes the fundamental rethinking and radical redesign of business flows to achieve significant and sustainable improvement in terms of quality, cost, service, lead time, and innovation (Hammer & Champy, 1993). So, analyzing production process is known to be a very essential stage in the BRP project. This is because the BRP recognizes the production workflow from start to

the end, indicates the issues, and the gaps between current operations and targeted results, and also determines the areas needed for modification (Lin, Fan, & Newman, 2009).

Hence, Woods (2013) identifies that in order to increase the productivity of the manufacturing industries; the production workflow is to be analyzed to determine the changes needed for improvement, which in turn improves the business of the company. This is because analysing workflow involves examine all processes of production to determine the ineffectiveness and to suggest solutions for improvement. The task starts with demonstrating expected outcomes and documents the current condition of the production process in the industries. At the end of the workflow analysis is the suggestion of process needed to be improves and automated.

As a result, this paper is about analysing the production workflow of manufacturing industries for finding out the solutions to improve production performance, increase the efficiency and effectiveness of manufacturing process. By using simulation as the key element to indicate the issues found in the selected company, the research results can be proposed as effective solutions to increase productivity and solve the business problems. Thus, a printing industry is selected to conduct research about evaluating production workflow using simulation. The modelling and simulation approach will be further explained in the research methodology.

## 1.2 PROBLEM BACKGROUND

Since the particular printing industry is systemized into three production departments such as pre-press, press, and post-press as shown in Figure 1.2, each department have different functions and operations that required to be monitored. As Bellander, Hanberg, and Stenberg (1997) has stated, with the current sophisticated production and the number of departments and workers included, it is critical to manage and monitor the entire process of production. This is because it is significant to manage the essential resources (material, equipment, people, and competence) efficiently and

effectively to be sustainable in the future. Unfortunately, many manufacturing industries still focus on the development of manufacturing machineries instead of the complete production workflow. Although most of the complex systems in the production lines have advance technical standard, yet Arborgh and Rosen (1996) says that there are still insufficient links in between of the systems and shortage of existing solutions on the market.

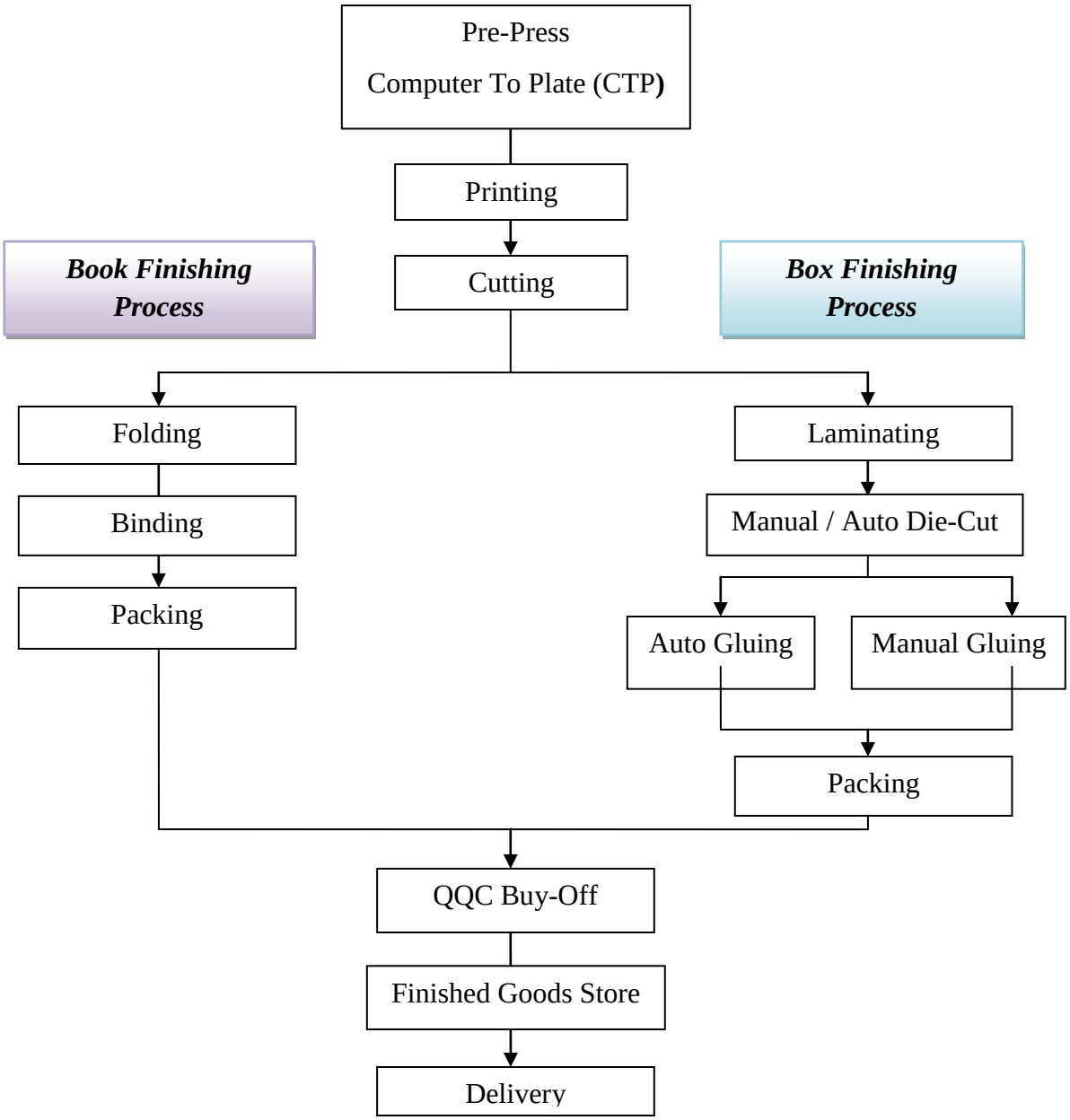


Figure 1.2: Production process of the printing industry.

Moreover, Peck, Sumarta, and Yeager (2009) explains that most of the operations process still lack of the process that can unify every levels of production, causing in separate stages of automating the production workflows.Since this particular printing industry is a well-known factory that produces books and boxes, the company has to meet constant demand and supply the products to local customers or high end international brands like Disney, Mattel, Sony, Avira, and Bosch. With the customers' continuous orders and requirements in terms of products and services, printing industry demand for enhancement in terms of improving the on-time delivery and respond to customers' needs with more flexibility. Hence, printing industries should focus on the increase of productivity by finding alternatives for better production workflow efficiency.

Besides that, cycle time of production is often related to the performance and efficiency of production process. The problems that caused longer cycle time may due to the operational models are artificially separates into three different departments such as pre-press, press, and post-press. The waiting time to transfer the entities or materials from one department to another will results in delays errors, and longer cycle time. Thus, the process of transferring the entities consumes a lot of time as it is done manually using pallets to transport the papers as a whole instead of using conveyer belt. This is because the production process has many workstations, which each station are situated with different machines and functions. Many other problems also occur in printing industry such as high work-in-process (WIP), layout narrow due to high WIP, and not enough skill operators. All of these issues are due to inefficient and ineffective production workflow (Peck et al., 2009).

## 1.3 PROBLEM STATEMENT

Based on the background of the problems, it is clear that inefficient and ineffectiveness of production workflow will cause longer setup time, higher Work-In-Process (WIP) resulting in longer cycle time of the production. After primary visits to the industry, it is found out that the printing firms use batch production methods due to

demands from different customers have several specifications and requirements in terms of quantity, quality, sizes and capacity. So, there is a high probability of poor work flow, particularly if the batches are not of the optimal size or if there is a significant difference in productivity by each operation in the process. Batch methods often result in the build up of significant work in progress (WIP) or stocks as the completed batches waiting for their turn to be worked on in the next operation.

In addition, many different processes, not just the manufacturing process, contribute to long cycle times. While all the delay may appear on the factory floor in the form of waiting (often more than 95% of the order-to-delivery cycle time consists of waiting), the causes for those waits stem from various processes both internal and external to manufacturing. When order-to-delivery problems are properly diagnosed, management almost always finds that one or more problems have contributed to the delay. As a result, analyzing the production workflow using modeling and simulation techniques are crucial to contribute in solving the problems.

Such complexities of manipulating flexible materials and dealing with constantly changing styles limit the degree of automation for the production system. Therefore, labour productivity and making production flexible are industry primary concern. Harrell, Ghosh, and Bowden (2004), clarifies that cycle time is the key to competitiveness of a firm as it affects both price and delivery schedule. Cycle time reduction is strongly correlated with high first pass yield, high throughput times, low WIP, low variability in process times, and subsequently cost. Thus, this study aims to model and simulate the production line and to propose improvement in the process and performance in order to reduce cycle time and so, increase output quantity (Yaakub, Ramlan, & Tan, 2012).

## 1.4 OBJECTIVES OF THE STUDY

1. To analyze the process of production in printing industry
2. To evaluate the problems of production workflow in printing industry

3. To propose the better operation for increasing the printing productivity and efficiency

## 1.5 RESEARCH QUESTIONS

1. What are the detailed processes of production in printing industry?
2. What are the problems that affect the production workflow in printing industry?
3. How to increase the efficiency and productivity of printing production?

## 1.6 METHOD OF ANALYSIS

The method of analyzing the production workflow for the printing industry is through modeling and simulation. Through modeling and simulation, a model can be generated virtually rather than physical experiments. So, using computer-generated prototypes can shorten the time taken to design significantly and reduces cost. Modeling and simulation also produces immediate results on design outcome promising a more complete evaluation of design solutions and a better performing finished model. Simulation is essentially crucial to model the multi-disciplinary systems in as the components have different disciplines such as mechanical, electrical, and embedded control, which are tightly connected to accomplish optimal system performance (Sinha, Liang, Paredis, & Khosla, 2001). The details for modeling and simulation will be further explained in Chapter 3.

## 1.7 SCOPE OF THE STUDY

There are extensive ranges of manufacturing industries in Malaysia; one of the production organizations is printing industry. Based on Mohamad's (2004) research, there are approximately 3000 printing industries and 400 publishing firms in Malaysia which play an important role in contributing to the country's economy. Consequently, one of the large commercial printing industries located in Penang, Malaysia is selected for this research. The reason for choosing larger industries is due to the availability of resources,

both financial and staff. In order to analyse the production workflow, one of the production lines for the soft cover books will be selected and taken for analysis. The production line covers the entire process from pre-press, press, to finishing and distribution. Next, the information data such as process flow and cycle time for each workstation in the production line selected will be gathered using observation. After that, the production system will be simulated by using the simulation software, ARENA.

## 1.8 SIGNIFICANCE OF THE STUDY

According to Cain and Haque (2008), analysis of production workflow has been used with the aim of increasing efficiency and effectiveness. In order to face the issues of customers' continuous demands, minimizing cycle time has become crucial. Analyzing the production process enable the redesign of existing workflow. Moreover, the research will be able to evaluate the performance measure of printing processes by using simulation. Through the modeling and simulation, the better operation process can be proposed to improve the printing productivity and at the same time create awareness of simulation effectiveness for the industry.

## 1.9 OPERATION DEFINITIONS

### 1.9.1 Workflow

Workflow is a collection of tasks organized to accomplish some business process. It also defines the order of task invocation or conditions under which task must be invoked, task synchronization, and information flow (Georgakopoulos, Hornick, & Sheth, 1995).

### 1.9.2 Productivity

"Productivity is a measure of the rate at which outputs of goods and services are produced per unit of input (labour, capital, raw materials, etc). It is calculated as the ratio of the

amount of outputs produced to some measure of the amount of inputs used. Productivity measures are used at the level of firms, industries and entire economies" (Parham, n.d.).

### 1.9.3 Cycle Time

Cycle time is the actual time to accomplish a task or process step. Several process steps may be necessary to complete the product. Cycle time is the maximum time that a product is allowed at each workstation (Heizer and Render, 2011).

### 1.9.4 Simulation

To quote from Shannon (1995), "the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system."

## 1.10 EXPECTED RESULT

The results are expected to be able to achieve the aims and purpose of the study. The finding may be able to answer the objectives and the scope of the study also. Since the workflow in commercial printing can pass through several departments in the industry, the new model for the production system will be developed. After developing of the model, the data and information will be transferred into the simulation software to generate the results. The results will be analysed and extract the solutions or alternatives for improving the printing process efficiency. The expected results are to develop and propose the alternatives that can enhance the production line, reduce quantity of cycle time, re-organize tasks for operators, and add a new workstation at the bottleneck area.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 INTRODUCTION

A literature review is an account of what has been published on a topic by accredited scholars and researchers. In this study, I have found out several articles about the topic of improving production workflow by using simulation. The purpose of the literature review is to convey the knowledge and ideas that have been established on this research topic. It acts as guidance for the research objectives in this case study. The strategy which writers used as a way to begin the literature review proceeded from the general, wider view of the research to the specific problem.

## 2.2 WORKFLOW

Workflow is defined as “automating the transfer of information to support the flow of work." Workflow empowers executives to alter the business process and place it under the control of software. Before, if an organization wanted to redesign a workflow without software support, the company would have to build or purchase new software. In contrast, today’s workflow eliminates this issue by reordering and formalizing the business process through software. The concept of flow can be regarded as two things when discussing processes. The workflow can either refer to the flow of information between individuals, or to the flow of activities to be done, each of which is assigned to a specific user within the

process. In some cases, it can be applied to both sending the jobs and associated information to the worker (Dun and Bradstreet Software Services, 1993).

Based on Cain and Haque (2008), workflow is defined as a set of tasks which grouped sequentially into processes or a set of people and resources needed to perform the given goals or tasks. An organization's workflow consists of the set of processes required to be completed, the set of people or resources available to accomplish those processes, and the interactions among them. Besides that, workflow or process is the sequence of the operation or the flow of the operation in manufacturing industry. Thus, analysis can be defined after the inspections of data or any problems or study on the case or statement that have been made experiment. Often, analysis is done after obtained the data through observation, researching, and also experiment (Mohd Zawawi, 2006).

In addition, a simple workflow is linear, meaning the next person in charge of handling the job is always the same and there are no changes to this situation. A simple workflow is indicated by a series of arrows pointing to the right; with each arrow indicate an element (Figure 2.2) (Kumar, 2010).

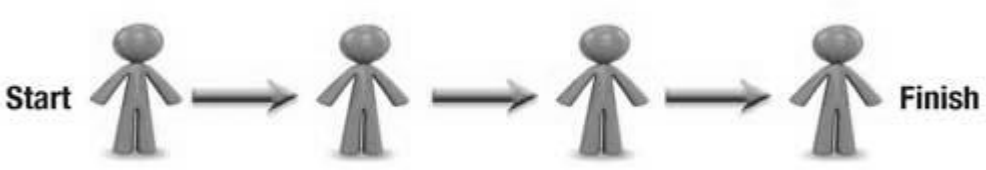


Figure 2.2: Simple Workflow.

### 2.2.1 Workflow Analysis

The phrase "workflow analysis" carries the meaning of construction and the use of systems models to support the analysis of material and energy transformation processes and the socioeconomic structures that control and influence these processes. In socioeconomic resource systems, workflow analysis is specially aims at explicating the evolution of the patterns of physical flow-physical stock. At the unit operation level,

process analysis will be used to support models and constructions of components that the systems are feasible because they are consistent with the physical laws of nature. These unit operations use the form of stock, appropriately controlled, to convert a set of flows of energy and material to another set. Next, at the plant level, workflow analysis supports the models and constructions of unit operations that can be coordinated for a specific reason such as the production of goods (Hoffman, McInnis, and Page, n.d.).

On the other hand, Hoffman et al. (n.d.) points out that at the corporate or company level, workflow analysis is used to support ongoing decision making concerning the performance of the extant plants and additions to the corporate portfolio. At the sub-national level, workflow analysis is used to support decisions concerning the coordination of regional development with all its concerns about zoning, tax base, employment and environmental impact. At the national level, workflow analysis is used to guide planning and policy as it partly represents the relationship of socioeconomic activity to the national resource base of a nation. At this level the concern with the resource base is both in its passive aspect as a source of materials and in its reactive aspect as a set of naturally occurring processes that must be used to ameliorate wastes. At the regional and global level, workflow analysis is used to examine potential trade patterns involving flows of materials, energy and service. This analysis supports decision making at the national level concerning trade agreements and industrial development strategy.

Next, Hoffman et al. (n.d.) further explain that workflow analysis is dynamic in two situations: one is that it connects levels, and the second is that the process based systems models change in time. This dynamic time dependence of workflow analysis has two attributes such as involutionary and evolutionary. The dynamic level connecting of workflow analysis produces significant distinction in the levels at which it is utilized. That distinction can be converted into the ratio of involutionary to evolutionary involvement of the decision making at each level.

### 2.2.2 Process Improvement

The theoretical framework of process improvement or workflow reengineering has gained distinctive values in the large business community over the last decade. Associated to process improvement is total quality management (TQM) and Six Sigma, which both required to improve production workflow to a point where they can no longer be improved (although maintenance of the process is still required). Therefore, the concept of workflow is completely corresponding with process in this context. Workflow improvement can be addressed as process improvement; process re-engineering can be identified as workflow re-engineering also. After adding the action into workflow, the process will be analyzed to investigate the way to re-engineer it so as to improve it the quality, at the lowest price, and the greatest speed (Mcllroy, n.d.).

## 2.3 PRODUCTIVITY

Parham (n.d.) reports that productivity is a measure of the rate at which outputs of products and services are manufactured per unit of input in terms of labours, capitals, and raw materials. Productivity is calculated as the ratio of the amount of outputs produced to some measure of the amount of inputs used. Productivity measures are used at the level of organizations, industries and entire economies. So, productivity calculations can have different interpretations depending on the context and the selection of input and output measures. Increasing productivity can have implications of economizing the function of inputs; for instance, adopting efficient production workflow that minimize waste. Improving productivity can also implicate the yielding of more outputs; for example, using resources in activities or with technologies that create more outputs. Abstractly, productivity is known as a supply-side measure, securing technical production relationships between inputs and outputs. Implicitly, productivity is also about manufacturing products and services that are valued, requested, and demanded.

Other than that, productivity as a very comprehensive concept as it has the common knowledge higher productivity leads to a reduction in cost of production, reduces the sales price of an item, expands markets, and enables the goods to compete effectively in the world market. Productivity also yields more wages to the employees, shorter working hours and greater leisure time for the workers. By enabling an increase in the output of products or services for existing resources, productivity decreases the cost of products per unit, and lower the prices, hence benefiting the customers and at the same time leaving a margin for increase in the wages of the employees (Production systems and operations management, n.d.).

$$\text{Productivity} = \frac{\text{Outputs}}{\text{Inputs}}$$

Productivity can be defined in many ways. Some of them are as follows (Production systems and operations management, n.d.):

- "Productivity is nothing but the reduction in wastage of resources such as labor, machines, materials, power, space, time, capital, etc.
- Productivity can also be defined as human endeavor (effort) to produce more and more with less and less inputs of resources so that the products can be purchased by a large number of people at affordable price.
- Productivity implies development of an attitude of mind and a constant urge to find better, cheaper, easier, quicker, and safer means of doing a job, manufacturing a product and providing service.
- Productivity aims at the maximum utilization of resources for yielding as many goods and services as possible, of the kinds most wanted by consumers at lowest possible cost.
- Productivity processes more efficient works involving less fatigue to workers due to improvements in the layout of plant and work, better working conditions and simplification of work. In a wider sense productivity may be taken to constitute the ratio of all available goods and services to the potential resources of the group."

### 2.3.1 How To Increase Productivity?

Based on Kumar (2010), the productivity can be increased by reducing the total cycle time. From the viewpoint of workflows, productivity can be improved by smoothing the production workflow or by decreasing processing time. Smoothing is done by reducing the number of elements while processing time can be reduced by decreasing the time spent on each element and the number of reworks; that is the number of times when the workflow is reversed to correct errors or to attain defined specifications.

***Reducing Cycle Time***

Cycle time is one of the challenges in textile and apparel industry, reducing cycle time is determined to be strongly correlated with high first pass yield, high throughput times, low variability in process times, low work-in-process (WIP), and cost. Consequently, cycle time is the key to competitiveness of an industry (Harrell et al., 2004).

Mohd Zawawi (2006) also recognizes cycle time as the time between successive units of the output from the process. Process cycle time is equivalent to the inverse of the throughput rate because it can be thought of as the time required for a task to repeat itself. Each sequence task in a workflow must have a cycle time less than or equal to the cycle time for the entire process. So, the process cycle time is equal to the longest task cycle time. In other definitions of cycle time is the maximum time allowed at each workstation to complete assigned tasks before the work continues.

$$\text{Cycle time} = \frac{\text{Production time available per day}}{\text{Units required per day}}$$

The cycle time is a direct measure of process and equipment performance is shown in Figure 2.3:

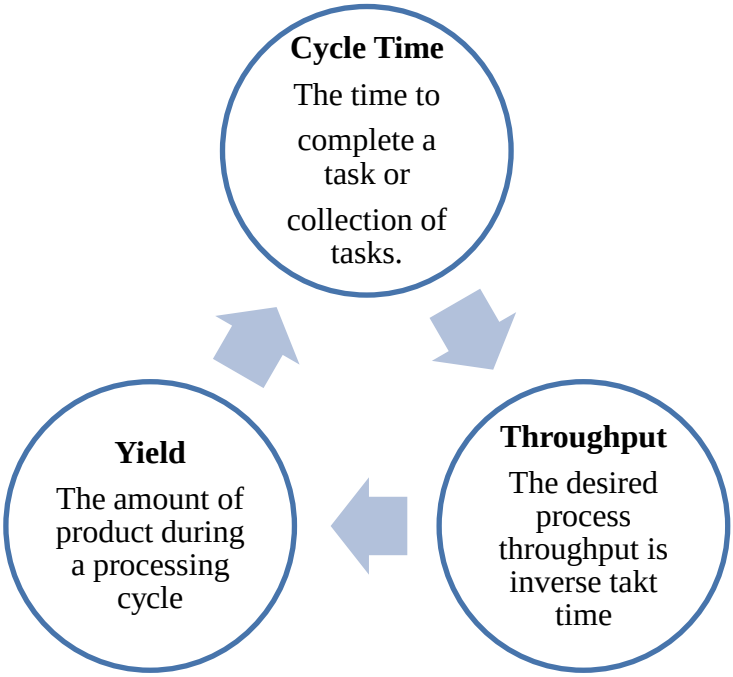


Figure 2.3: The relationships between cycle time, throughput, and yield.

***Reduce Repetition***

Kumar (2010 further indicates that reduce repletion can increase productivity. First, the management has to eliminate any unnecessary elements found in workflow, especially in unplanned and unmanaged ones, elements tend to get added over time. Second is by reducing the time for individual elements. This is due to analyzing the remaining elements are crucial to estimate the production time taken. Third is to run elements in parallel as unmanaged workflows have another bad tendency to become completely sequential. Meaning, each element has to wait and queue for all others before it to complete. The alternatives may be place more than one element and run in parallel to save the time.

***Work In Process (WIP)***

Moreover, Palaniappan, Sawhney, Bashford, and Walsh (2007) suggest that reducing work-in-process (WIP) can increase the rate of production also. Work in process (WIP) indicates to the number of work items that are in progress in a construction process. WIP can be estimated by computing the number of work items that are in progress each week during the simulation period. The number of work items in this calculation refers to both work items that undergo construction and rework process and the work items that wait for the re-source. WIP plots can be used to study workflow issues such as the performance of a process or to identify bottle-neck associated with a process, and also to calculate inventory holding costs.

## 2.4 EFFECTIVENESS

Effectiveness is about the degree of accomplishment of the objectives that. Effectiveness is also about accomplishing the desired outcomes. Effectiveness may reflect output quantities and perceived quality. Effectiveness can also be defined as doing the right things (Production systems and operations management, n.d.).

## 2.5 EFFICIENCY

This situation happens when a certain output is achieved with a minimum of inputs. The desired outputs can be raised by reducing the down times as much as possible such as coffee breaks, machine failures, and waiting time. However, if the down times are decreased, the frequency of occurrence of defective products will increase due to tiredness of the workers. The production system might produce products inefficiently. While efficiency is referred as doing things right, operational efficiency means a ratio of outputs to inputs, like land, capital, and labour (Production systems and operations management, n.d.).